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TABLE *A*

Family	Maternal Ratio	Offspring	
		Mode	Mean
5a	1.46	1.50–1.59	1.49
5c	1.32	1.50–1.59	1.61
5b	1.22	1.50–1.59	1.47

The table shows clearly that while the range in the maternal ratio is .24, the range in the means is only .14 and that there is no close relation between the order of the maternal ratios and the order of the fraternal means. In all the fraternities the mode stands in the 1.50–1.59 class.

CONCLUSIONS

In so far as this series goes, then, it speaks for the conclusion that, in the parthenogenetic *Aphis rumicis,* the progeny does not inherit the somatic idiosyncrasies of the parent but does inherit from the underlying germ plasm common to all; and hence progeny of somatically quite different sisters tend, on the average, to be alike. The somatic differences in the parthenogenetic line are not inherited.

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THE HIMALAYAN RABBIT CASE, WITH SOME CONSIDERATIONS ON MULTIPLE ALLELOMORPHS

IT has been shown by Castle ('06, '09), Hurst ('06) and Punnett ('12) that the Himalayan pattern in rabbits behaves as a simple recessive to self color, and as a simple dominant to albino. Thus, as Punnett points out, we might suppose self to be the double dominant, Himalayan a recessive in one factor, and albino a double recessive. But, to use Punnett's words:

The F_2 from self × albino should consequently contain Himalayans as well as true albinos. But among the large number of animals reared from such matings no Himalayans have hitherto been recorded, and for the present the relations between these various forms remain obscure.

If we suppose that albino may be either the second single recessive or the double recessive we avoid this difficulty, but are then unable to explain why albino × Himalayan should not, at least occasionally, produce selfs by recombination.

Now it seems to me that the facts of the case are fitted equally well by either of two hypotheses. In the first place, we may consider, as above, that Himalayan is a single recessive and albino a double recessive—if we suppose the two factors concerned to be completely linked. The gametic (not zygotic) constitution of the three types would then be represented thus, C being the color producer and S the factor changing Himalayan to self.

Self — CS
Himalayan — Cs
Albino — cs

If C and S be completely linked no cS individual can be obtained, and CS × cs would give no Cs in F_2.

On the other hand, we may consider the factor for self as allelomorphic to that for Himalayan pattern, and also to that for albinism. Then the three pure types might be represented thus (zygotic formulæ):

Self — SS
Himalayan — HH
Albino — AA

S, H, and A being allelomorphic each to itself or to either of the others, the crosses would result thus:

Self — SS
Himalayan — HH

F_1 SH — self

$$F_2 \quad \left\{\begin{array}{l} \left.\begin{array}{l} SS \\ SH \\ SH \end{array}\right\} \text{3 self} \\ HH \text{ — 1 Himalayan} \end{array}\right.$$

Self — SS
Albino — AA

F_1 SA — self

$$F_2 \quad \left\{\begin{array}{l} \left.\begin{array}{l} SS \\ SA \\ SA \end{array}\right\} \text{3 self} \\ AA \text{ — 1 albino} \end{array}\right.$$

$$\begin{array}{ll} \text{Himalayan} & — HH \\ \text{Albino} & — AA \\ \hline F_1 & HA — \text{Himalayan} \\ \hline F_2 & \begin{cases} \left.\begin{array}{l} HH \\ HA \\ HA \end{array}\right\} 3 \text{ Himalayan} \\ AA — 1 \text{ albino} \end{cases} \end{array}$$

An explanation similar to the second one above has been given by de Meijere ('10) for Jacobson's results with *Papilio Memnon.* The evidence on this case is, however, very incomplete, and there are complications due to sex. Either triple allelomorphs or complete coupling would seem to cover the facts as we have them at present. Shull ('11) has also used a system of three allelomorphs for a case in *Lychnis dioica.* I shall refer to this case again.

It will be seen that triple allelomorphs may be substituted for complete coupling as an explanation of any case where only three of the four combinations possible on the complete coupling scheme are known. But if we have the double dominant, both single recessives, and the double recessive, then triple allelomorphism will no longer work. Thus, if a race of albino rabbits is discovered which produces self when mated to Himalayan, complete linkage will be the most likely explanation of the case.

There are certain other cases which fulfil the above requirements. Emerson ('11) has reported a case in beans (green leaves—green pods, green leaves—yellow pods, and yellow leaves—yellow pods are the three races concerned). The similar cases of complete linkage reported for corn by East and by Emerson are probably more easily explainable by linkage than by multiple allelomorphs, as, at least in some cases, all four possible races are found. Baur ('12) has a case in *Aquilegia,* where three types of leaves are found—green, variegated (green and yellowish green), and yellowish green. These behave toward each other in a manner exactly similar to that of the self, Himalayan and albino rabbits. Finally, Morgan ('12) has reported a case in *Drosophila ampelophila.* Red eye is a dominant to eosin and to white, and eosin is also a dominant to white. No two types ever give the third when crossed, either in F_1 or in F_2. The explanation which has been given in beans, columbines and flies has been that of two allelomorphic pairs, completely linked to each other.

The question as to which of these views is the more probable is closely bound up with the presence and absence hypothesis. On a strict application of this idea there is of course no possibility of more than two members of any given allelomorphic group. The presence and absence hypothesis as a universal principle has been criticized by Morgan ('13) in a recent paper, on what seem to me very strong grounds. It seems very unlikely that protoplasm (chromatin?) is such a simple substance that the only possible change in a given unit (molecule?) involves the loss of that unit. On the other hand, if a slight change takes place in a chemically complex gene, is it necessary to suppose that its allelomorphic relations must be upset? That very slight changes in the constitution of a gene might easily affect its behavior in ontogeny will, I think, be readily granted.

It is to be noted that in all the cases cited above the supposed three allelomorphs have similar ontogenetic effects. Thus the three in rabbits, in *Aquilegia,* and in *Papilio* all affect the distribution of pigment (and, in *Papilio,* also the shape of the wings), those in *Lychnis* the sex, those in beans the production of the same color in different organs, and those in *Drosophila* the production of different colors in the same organ. This may perhaps seem to be in favor of the view that we have here different modifications of the same gene, rather than two distinct genes and their absences.

The history of the red-white-eosin group of eye colors in *Drosophila* is interesting when considered from the viewpoint of the presence and absence hypothesis. The first white-eyed fly arose as a mutant in red stock. On presence and absence it must have been caused by the simultaneous loss of two factors, which were called *C* and *O* by Morgan. Then, in white-eyed stock there appeared an eosin-eyed fly. Here the factor called *O,* just lost, must have been put back again. Finally, in one of my own cultures, eosin has given rise to white by mutation.[1] In both these latter cases the flies had miniature wings, and in the white-to-eosin case they also had black body color. These characters give a check on the results, and make it extremely unlikely that any contamination had occurred. Further evidence to this effect is given, in the eosin-to-white case, by the fact that the mutant fly was one of 127 obtained from a single pair, all of her brothers and sisters being of the expected classes (half of the females heterozygous for white), as were likewise the flies from six sister pairs.[2]

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[1] After this paper went to press it was pointed out to me by Mr. H. J. Muller that there is another possible explanation of this case, which does not involve mutation from eosin to white. This interpretation can not be entered into until certain phenomena observed by Mr. C. B. Bridges have been more fully investigated.

The presence and absence hypothesis involving a dropping out of whole genes or addition of entirely new ones does not offer as simple an explanation of this case as does the conception that we have here a relatively unstable gene, which does not drop out entirely, but undergoes various changes, that from white to eosin being reversible.

It should be noted that Shull ('11) has reported a case of what he calls reversible mutation in the sex-determining factor in *Lychnis,* which is very similar to the above red-eosin-white case. He has adopted a system of triple allelomorphs to explain it, though admitting that complete linkage will also cover the facts. He has also considered the bearing of the case upon the presence and absence hypothesis and upon the nature of mutation, reaching conclusions somewhat similar to those given above.

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[2] There has been at least one case where eosin has seemed to arise as a mutant in red stock, but as there was no other character to serve as a check against contamination, the case does not carry very great weight.

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MENDELISM AND INTERSPECIFIC HYBRIDS

The complications of modern Mendelism have greatly increased the difficulty of discussing the practical applications of heredity. The word Mendelism itself has two essentially different meanings that are being used indiscriminately. A particular form of alternative inheritance is called Mendelism and the same name is applied to a general theory of heredity. It is true that the Mendelian theory was suggested by the Mendelian form of inheritance, but the facts are also capable of other interpretations. Many of the proposed applications of Mendelism to breeding and eugenics are in reality only inferences from the theory and are not in real accord with the facts on which they are supposed to be based.

An example of such a discrepancy may be found in the American Naturalist for July, 1912, in a paper entitled: "Evidence of Alternative Inheritance in the F_2 Generation from Crosses of *Bos indicus* on *Bos taurus*." Though readers are evidently expected to believe that the hybrids are showing a typical Mendelian inheritance of the contrasted parental characters, the facts stated in the paper show that the behavior of the hybrids is not in accord with the Mendelian theory of heredity. Alternative inheritance is manifested in these bovine hybrids, but it is not the Mendelian form of alternative inheritance, with the contrasted parental characters behaving as independent units combined by the laws of chance. Instead of showing a Mendelian freedom of combination of the contrasted characters, these hybrids afford a much better illustration of a different principle of heredity, the coherence of characters derived from the same parental stock.

As the paper by Dr. Nabours seems to represent the only attempt that has been made to give a scientific account of a unique series of hybrids, it would be very undesirable to have the general conclusion regarding the application of Mendelism accepted without challenge. In addition to the scientific questions involved, the importance of finding the best way of securing a full utilization of the tick-resistant Brahma cattle in Texas will appeal to all who have had the pleasure of seeing Mr. Borden's imported animals and their hybrid offspring. But practical recommendations are hardly in order until the facts are better under-